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IMPROVEMENT OF INITIATOR FIRING MECHANISMS

by

J. M. Di Phillipo

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DA Project 5S02-06-001

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IMPROVEMENT OF INITIATOR FIRING MECHANISMS

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ABSTRACT

This report describes in detail the accomplishments made in the design and development of an initiator that could be fired by either a mechanical, an electrical, or a gas pressure source.

Twenty-eight test firings were conducted at 70° F to prove the feasibility of this design and obtain performance characteristics.

Initiators can be provided with multi-means of firing and would provide an advantage to user personnel.

INTRODUCTION

This is the final report describing, in detail, the accomplishments toward improvement, by redundancy, of the initiator firing mechanisms.

The program was initiated by the National Engineering Branch, Procurement Division, Industrial Group, Frankford Arsenal. The design and development was accomplished by the Engineering Design Branch, Propellant Actuated Devices Division, Frankford Arsenal.

Standard initiator designs usually comprise a single method of firing based on the operation of a mechanism powered by a mechanical spring or gas pressure. In addition, electrically actuated initiators have been used to a lesser extent.

A proposal was submitted to the Industrial Group for the design and development of an initiator that could be fired by either a mechanical, an electrical, or a gas-pressure source. The selective firing of this initiator would be an overall improvement of the present design, due to the redundancy which provides the choice of one of three methods of actuation.

GENERAL

Design studies were conducted on the mechanical and gas fired initiators. In order to provide multi-choice firing mechanisms for initiators operating either by mechanical means or by gas pressure, consideration was made of both the standard mechanical and gas-fired, singly operated mechanisms.

The standard mechanical method of firing operates by pulling a lanyard pin, which is coupled to the spring loaded firing pin by means of a ball release mechanism. When the lanyard pin has been pulled to the point of release, the firing pin disengages and travels under the action of the firing pin spring, to impact against the percussion primer.

The gas-fired initiators operate when supplied with a gas pressure which produces a load exceeding the shear value of the shear pin that restrains the firing pin. The firing pin then travels under the action of this predetermined pressure and impacts the percussion primer. From a mechanism standpoint, limited review of electrical firing was necessary because this type of firing is simply accomplished by means of an electrical ignition element or an electrical primer.

In order to incorporate the mechanical and gas firing features, a design was conceived that utilized a concentric piston which operated around the mechanical firing mechanism. The piston and lanyard pin were held by means of a single safety pin which prevented inadvertent firing by either method. Mechanical firing is accomplished in the standard manner, but gas firing is achieved by means of the concentric piston that acts upon the lanyard pin when gas pressure is introduced into the gas inlet port on the side of the firing head. The piston serves to extract the lanyard pin, after which the firing proceeds in the same manner as a mechanical firing.

To incorporate an electrical firing capability, together with the mechanical and gas pressure firing concept, means were sought which would not alter the standard percussion primer cartridge case.

A simple means for accomplishing this was attempted by providing threaded bosses on the side of the initiator chamber body. The XM21 electrical ignition elements were screwed into these bosses. The basic idea of this method is that the firing of the electrical ignition elements will blast a hole into the side of the cartridge case and that the propellant will ignite and burn in the usual manner.

PROCEDURE

Two working test models were fabricated for preliminary tests, according to the drawing shown in Figure 1. The gas port bosses for electrical ignition were machined separately and silver-soldered onto the chamber body of the initiator. This was done to reduce the cost of the test models.

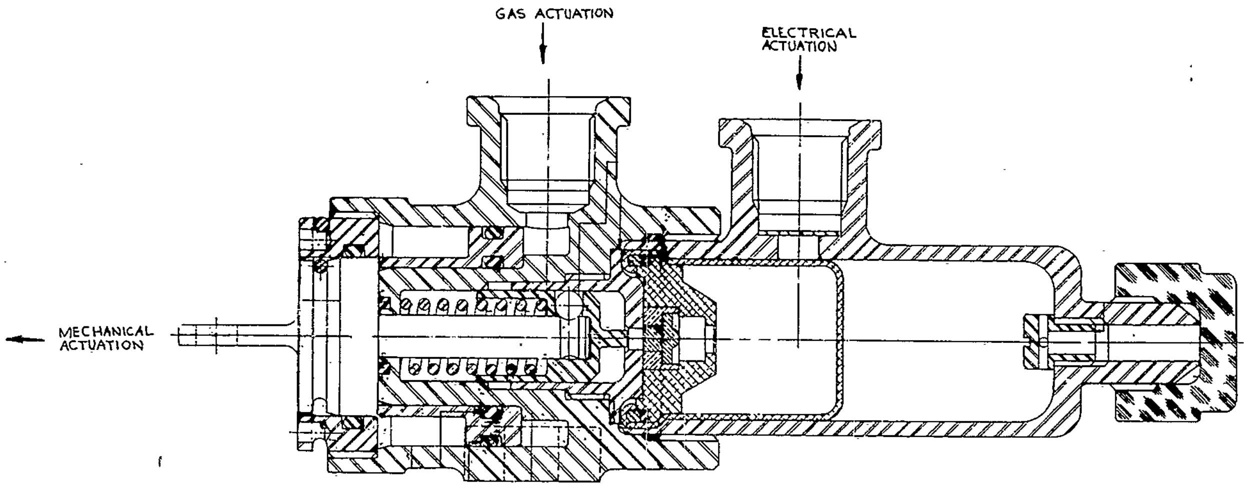

Figure 1. Initiator Assembly

Twenty-eight test firings were conducted at 70° F to prove feasibility and to obtain performance characteristics.

Ten test firings were conducted utilizing only the mechanically operated portion of the initiator. For these tests the ports in the chamber body were plugged to prevent gas leakage. Firing of the cartridge was accomplished by pulling the lanyard pin in the usual manner. These tests were successful since the functioning of all the cartridges was normal and examination indicated that there were no visible deformations of the initiator parts.

For the ten tests of the gas-pressure-operated portion of the initiator, a standard M3 initiator was coupled to the gas inlet port by a 25-foot length of hose. During firing, the gas pressure was introduced into the multi-firing head, onto the effective area of the concentric piston, to produce a force to extract the lanyard, thereby cocking and releasing the firing pin in one motion. These tests were highly successful and proved that the mechanical and gas pressure means of actuation functioned satisfactorily.

The third method of firing this initiator utilized an electrical means. In accordance with the work statement, two XM21 ignition elements were used to fire the cartridge. These elements were inserted into the threaded bosses provided on the initiator chamber. A series of tests was conducted at room temperature to prove the feasibility of firing an electrically actuated XM21 ignition element directly into the cartridge case. The results of these tests were not satisfactory.

Due to the fact that this initiator contained a comparatively short cartridge case and that the blast from the electrical ignition element was directed onto the case wall near the base of the cartridge case, deformation occurred without rupture, and the propellant did not ignite. Instead, the gas expanded into the main chamber volume as soon as the case deformed and the flash was cooled without coming into contact with the propellant.

Two means of correcting this condition were considered:

1. Provide a gas seal between the chamber and case to prevent diversion of the blast and flash.

2. Provide a blow-out disc to increase the blast pressure and to provide a metallic mass to assist in rupturing the case.

It was decided to try the second method because of its simplicity. Therefore, a steel disc, 3/8 inch in diameter and 0.020 inch thick, was inserted into the gas ports in the chamber bosses prior to the insertion of the XM21 electrical ignition elements. Tests conducted with this type of modification proved highly successful. Round-by-round data of all tests were recorded. See Appendix.

This concluded the feasibility study of the multi-operated initiator firing mechanisms.

Efforts were then directed toward the development of a prototype model incorporating these mechanisms.

Pattern drawings of the new head and chamber design were made and processed to the shop for fabrication of a mold to produce ten investment castings. The castings were made of 4340 steel. These castings were not finish-machined because funds were depleted and work on this project was discontinued.

CONCLUSIONS

1. Initiators can be provided with selective multi-means of firing in the manner described in this report.

2. The application of these means of providing the improved redundant firing mechanism to initiators would provide an advantage to user personnel because of the selective means of firing and the additional reliability.

RECOMMENDATIONS

1. It is recommended that funds be provided to complete the development of initiators with selective firing mechanisms because of the apparent success of this program.

2. It is recommended that a type of initiator having selective firing mechanisms be added to the "family" of initiators currently available.

APPENDIX

EXPLANATION OF FIRING DATA

There were three types of firings conducted on the improved mechanized initiators - mechanical, gas, and electrical. The mechanical test firings, shown in Table I, consist of two types of test. Rounds from 1 to 5 were fired by pulling a lanyard pin, as on the conventional mechanical initiator, and sealing off the electrical port located on the chamber so as to contain the gases in the chamber. Rounds from 6 to 10 were fired by pulling the lanyard pin as above, but instead of sealing the electrical port, two XM21 electrical ignition elements were inserted; these elements fired after the cartridge burst. These tests proved successful due to no harmful effect to the initiator, and normal pressures were recorded in a one cu. in. pressure block and 15 ft of flexible hose (MS28741-4).

Table II, A and B (rounds 11 through 20), cover firings similar to the above, the difference being the tests were performed by firing an M3 initiator through a 25-ft hose to direct the gases to a piston that released the lanyard pin to fire the cartridge. These tests proved successful. The "A" portion of the table shows the pressures going into the system to actuate the piston and the "B" section records the pressures going out of the system.

Tests reported in Table III were conducted by using the electrical ignition element, XM21, to fire the cartridge by blasting directly into the cartridge. Only one round was successful; the cartridge failed to fire with six initiators with one electric element and with four initiators with two electric elements. The successful firing was an initiator with two electric elements. In this firing, the cartridge fired, blowing off one element. Delay time and port pressures could not be evaluated.

A small round disc was designed and inserted into the port that houses the electrical ignition element. This disc was 3/8 in. in diameter and 0.020 in. thick. The purpose of this disc was to have the pressures produced by the ignition element build up momentarily. This allows the pressure to enter the cartridge case with greater force and ignites the propellant without going through the firing pin primer system. These tests proved successful, and results are given in Table IV.

TABLE I. Round by Round Firings - Mechanical

Round No.	Temp (° F)	Function	Ignition Delay (msec)	Rise Time (msec)	Pressure (psi)
		Without Element			
1	70 ± 5	OK	17	11	660
2	70 ± 5	OK	18	10	700
3	70 ± 5	OK	18	12	1100
4	70 ± 5	OK	17	11	670
5	70 ± 5	OK	14	12	1010
		With Element			
6	70 ± 5	OK	18	10	870
7	70 ± 5	OK	13	12	700
8*	70 ± 5	OK	14	12	990
9*	70 ± 5	OK	14	12	770
10*	70 ± 5	OK	16	11	920

TABLE II. Round-by-Round Firings - Gas (M3 Initiator fired through 25 ft of hose)

			A			B		
				Pressure (psi)				
Round No.	Temp (° F)	Function	Ignition Delay (msec)	M3 Initiator Peak	Piston Actuating	Ignition Delay (msec)	Rise Time (msec)	Pressure* (psi)
				Without Element				
11	70 ± 5	OK	19	580	190	14	14	1100
12	70 ± 5	OK	23	630	200	17	14	950
13	70 ± 5	OK	26	530	180	18	14	900
14	70 ± 5	OK	25	500	140	17	12	1100
15	70 ± 5	OK	25	460	140	17	15	810
				With Element				
16	70 ± 5	OK	30	510	130	16	11	1080
17	70 ± 5	OK	31	410	140	18	10	1010
18**	70 ± 5	OK	33	240	120	13	11	940
19**	70 ± 5	OK	17	630	180	17	9	920
20**	70 ± 5	OK	Lost delay	410	130	15	10	940

*Recorded at termination of 15 ft of hose
**Element set off when cartridge fired

NOTE: "A" portion of the table shows the pressures going into the system to actuate the piston; "B" portion records the pressures going out of the system.

TABLE III. Round-by-Round Firings - Electrical

Round No.	Temp (° F)	Function	Ignition Delay (msec)	Rise Time (msec)	Pressure (psi)
		With Two Electric Elements			
21	70 ± 5	OK	28	10	670

NOTE: 6 initiators with 1 electric element - cartridge failed to fire.
4 initiators with 2 electric elements - cartridge failed to fire.
1 initiator with 2 electric elements - cartridge fired, blowing off one element; delay time and port pressure could not be evaluated.

TABLE IV. Round-by-Round Firings - Electric
(With 3/8 in. Disc inserted)

Round No.	Temp (° F)	Function	Ignition Delay (msec)	Rise Time (msec)	Pressure (psi)
22	70 ± 5	OK	22	13	730
23	70 ± 5	OK	26	15	690
24*	70 ± 5	Body split	-	-	-
25	70 ± 5	OK	29	12	800
26	70 ± 5	OK	39	14	660
27	70 ± 5	OK	26	24	530
28	70 ± 5	OK	38	9	690

*Body rupture, due to inferior welding

NOTES: Rounds 22 and 23 fired electrically, with two elements and two pointed discs; rounds 24 through 28 fired electrically with one element and one flat disc.

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